

WHAT IS CLAIMED IS:

1        1. A method for determining segment bandwidth capacity of a test segment in a  
2 network, the method comprising:

3                 sending a plurality of packet profiles from a plurality of source nodes to a  
4 plurality of destination nodes via links, each link connecting a source node with a destination  
5 node, each link including the test segment;

6                 manipulating start times for sending the plurality packet profiles, or a portion  
7 thereof, from the plurality of source nodes, or a portion thereof, so that the plurality of packet  
8 profiles flow through the test segment essentially simultaneously; and

9                 receiving the plurality of packet profiles at the plurality of destination nodes,  
10 wherein each of the packet profiles comprises a plurality of packets, and byte count  
11 measurements and time stamps are made at the plurality of destination nodes.

1        2. The method of claim 1, wherein a central server is utilized to command the  
2 plurality of source nodes to send the plurality of packet profiles at specific times, including the  
3 manipulation of the start times for the plurality of packet profiles.

1        3. The method of claim 1, wherein the network is a time synchronized network and  
2 each of the plurality of packet profiles is a packet burst.

1           4.     The method of claim 3, wherein the length L of each of the packet bursts is  
2     related to the Degree of Desynchronization (DoD) by an expression,  $L = \frac{DoD}{ErrLim}$ , where ErrLim  
3     represents a maximum desired error in the segment bandwidth capacity determination.

1           5.     The method of claim 4, wherein the time stamps made at each of the plurality of  
2     destination nodes are a first time stamp  $TS_{first}$  of the first packet of the packet burst received from  
3     each corresponding source node and a last time stamp  $TS_{last}$  of the last packet of the packet burst  
4     received from each corresponding source node, and the byte count measurements measure the  
5     bytes  $Bytes_{total}$  in each of the packet bursts received at each corresponding destination node.

1           6.     The method of claim 5, wherein an individual flow rate in bit per second due to  
2     each packet burst is calculated using an expression,  $Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}$ , and a total flow  
3     rate through the test segment is the sum of all individual flow rates.

1           7.     The method of claim 1, wherein the network is a non-time synchronized network  
2     and each of the plurality of packet profiles is a packet stream, and a plurality of byte count  
3     measurements are made over a time measurement period T at each of the plurality of destination  
4     nodes.

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2           8.     The method of claim 7, wherein the length  $L_{multiple}$  of the packet stream is related  
3     to the Degree of Desynchronization (DoD) by an expression,  $L_{multiple} = (4 * T) + 2\epsilon$ , where the

4 time measurement period T is one half of DoD and epsilon ε is used to compensate for small  
5 timing errors.

1 9. The method of claim 8, wherein the time stamps made at each of the plurality of  
2 destination nodes are a plurality of time measurements MT<sub>n</sub>, where n is an integer, each time  
3 measurements MT<sub>n</sub> being separated by the time measurement period T and each measuring byte  
4 count over the period T since last time measurement MT<sub>n-1</sub> in each of the packet streams  
5 received at each corresponding destination node.

1 10. The method of claim 9, wherein an individual flow rate in bit per second due to  
2 each packet stream at the test segment is related to the smallest byte count measurement Bytes<sub>total</sub>  
3 of all byte count measurements taken for the packet stream, the individual flow rate being  
4 calculated using an expression, Rate(bps) =  $\frac{Bytes_{total} * 8}{MT_n - MT_{n-1}}$ , and a total flow rate through the test  
5 segment is the sum of all individual flow rates.

1 11. The method of claim 1, wherein a link bandwidth capacity of a link is determined  
2 by measuring the bandwidth capacity of each of the segments that make up the link, the link  
3 having a maximum throughput of the slowest segment in the link.

1 12. A method for determining bandwidth capacity of a test segment in a time  
2 synchronized network, the method comprising:

3                    sending a packet burst from a source node to a destination node via a link, the link  
4                    including at least the test segment; and  
5                    receiving the packet burst at destination node, the packet burst comprising a  
6                    plurality of packets, wherein a first time stamp  $TS_{first}$  of the first packet of the packet burst, a last  
7                    time stamp  $TS_{last}$  of the last packet of the packet burst and a byte count measurement measuring  
8                    the bytes  $Bytes_{total}$  in the packet burst are made at the destination node, the bandwidth capacity of  
9                    the test segment in bit per second being calculated using an expression,

$$10 \quad Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}.$$

1                    13.        The method of claim 12, wherein the length L of the packet burst is related to the  
2                    Degree of Desynchronization (DoD) by an expression,  $L = \frac{DoD}{ErrLim}$ , where ErrLim represents a  
3                    maximum desired error in the bandwidth capacity determination

1                    14.        A method for determining bandwidth capacity of a test segment in a non-time  
2                    synchronized network, the method comprising:  
3                    sending a packet stream from a source node to a destination node via a link, the  
4                    link including at least the test segment, the packet stream having a length  $L_{single}$  that ensures at  
5                    least two measurements for byte count measurement can be made at the destination node;  
6                    receiving the packet stream at destination node, the packet stream comprising a  
7                    plurality of packets;

8                   taking at least two measurements  $MT_{first}$ ,  $MT_{second}$  at the destination node while  
9       the packet stream is being received, the two measurements  $MT_{first}$ ,  $MT_{second}$  being separated by a  
10      measurement period T; and

11                   making a byte count measurement measuring the bytes  $Bytes_{total}$  in the packet  
12      stream between the measurements  $MT_{first}$ ,  $MT_{second}$  at the destination node, the bandwidth  
13      capacity of the test segment in bit per second being calculated using an expression,

$$14 \quad Rate(bps) = \frac{Bytes_{total} * 8}{MT_{second} - MT_{first}}.$$

1                 15.     The method of claim 14, wherein the length  $L_{single}$  of the packet stream is greater  
2       than or equal to  $(2 * T) + 2\epsilon$ , where epsilon is used to compensate for small timing error.

1                 16.     The method of claim 14, further comprising triggering the destination SN to take  
2       the first measurement  $MT_{first}$  when it receives the first few packets in the packet stream, wherein  
3       the length  $L_{single}$  of the packet stream is greater than or equal to  $T + 2\epsilon$ , where epsilon is used to  
4       compensate for small timing error.

1                 17.     A network system for determining bandwidth capacity of a test segment in a  
2       network, comprising:

3                   a plurality of links interconnecting nodes residing on the edge of the network,  
4       each of the link being made up of at least one segment;  
5                   a plurality of source nodes that send a plurality of packet profiles for traveling  
6       through links, each link including the test segment, the plurality of packet profiles, or a portion

7 thereof, being sent at specific times so that the plurality of packet profiles flow through the test  
8 segment essentially simultaneously;

9 a plurality of destination nodes that receive the plurality of packet profiles,  
10 wherein each of the packet profiles comprises a plurality of packets, and byte count  
11 measurements and time stamps are made at the plurality of destination nodes.

1 18. The network system of claim 17, further comprising a central server that  
2 commands the plurality of source nodes to send the plurality of packet profiles at specific times,  
3 including the manipulation of start times for the sending of the plurality of packet profiles, or a  
4 portion thereof.

1 19. The network system of claim 17, wherein the network is a time synchronized  
2 network and each of the plurality of packet profiles is a packet burst.

1 20. The network system of claim 19, wherein the length L of each of the packet bursts  
2 is related to the Degree of Desynchronization (DoD) by an expression,  $L = \frac{DoD}{ErrLim}$ , where  
3 ErrLim represents a maximum desired error in the segment bandwidth capacity determination.

1 21. The network system of claim 20, wherein the time stamps made at each of the  
2 plurality of destination nodes are a first time stamp  $TS_{first}$  of the first packet of the packet burst  
3 received from each corresponding source node and a last time stamp  $TS_{last}$  of the last packet of  
4 the packet burst received from each corresponding source node, and the byte count

5 measurements measure the bytes Bytes<sub>total</sub> in each of the packet bursts received at each  
6 corresponding destination node.

1           22. The network system of claim 21, wherein an individual flow rate in bit per second  
2 due to each packet burst is calculated using an expression,  $Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}$ , and a total  
3 flow rate through the test segment is the sum of all individual flow rates.

1           23. The network system of claim 17, wherein the network is a non-time synchronized  
2 network and each of the plurality of packet profiles is a packet stream, and a plurality of byte  
3 count measurements are made over a time measurement period T at each of the plurality of  
4 destination nodes.

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2           24. The network system of claim 23, wherein the length L<sub>multiple</sub> of the packet stream  
3 is related to the Degree of Desynchronization (DoD) by an expression,  $L_{multiple} = (4 * T) + 2\epsilon$ ,  
4 where the time measurement period T is one half of DoD and epsilon  $\epsilon$  is used to compensate for  
5 small timing errors.

1           25. The network system of claim 24, wherein the time stamps made at each of the  
2 plurality of destination nodes are a plurality of time measurements MT<sub>n</sub>, where n is an integer,  
3 each time measurements MT<sub>n</sub> being separated by the time measurement period T and each  
4 measuring byte count over the period T since last time measurement MT<sub>n-1</sub> in each of the packet  
5 streams received at each corresponding destination node.

1           26.     The network system of claim 25, wherein an individual flow rate in bit per second  
2     due to each packet stream at the test segment is related to the smallest byte count measurement  
3     Bytes<sub>total</sub> of all byte count measurements taken for the packet stream, the individual flow rate  
4     being calculated using an expression,  $Rate(bps) = \frac{Bytes_{total} * 8}{MT_n - MT_{n-1}}$ , and a total flow rate through  
5     the test segment is the sum of all individual flow rates.

1           27.     The network system of claim 17, wherein a link bandwidth capacity of a link is  
2     determined by measuring the bandwidth capacity of each of the segments that make up the link,  
3     the link having a maximum throughput of the slowest segment in the link.

1           28.     The network system of claim 17, wherein the nodes are distributed at the edges of  
2     the network and exist in stand-alone boxes.

1           29.     The network system of claim 17, wherein the nodes are added as software  
2     modules to existing end hosts or network devices.

1           30.     A computer readable medium for use in conjunction with a network system  
2     including a plurality of nodes for determining segment bandwidth capacity, the computer  
3     readable medium including computer readable instructions encoded thereon for:  
4                 sending a plurality of packet profiles from a plurality of source nodes to a  
5     plurality of destination nodes via links, each link connecting a source node with a destination  
6     node, each link including the test segment;

7                manipulating start times for sending the plurality packet profiles, or a portion  
8        thereof, from the plurality of source nodes, or a portion thereof, so that the plurality of packet  
9        profiles flow through the test segment essentially simultaneously; and  
10              receiving the plurality of packet profiles at the plurality of destination nodes,  
11        wherein each of the packet profiles comprises a plurality of packets, and byte count  
12        measurements and time stamps are made at the plurality of destination nodes.

1                31.        The computer readable medium of claim 30, wherein the network is a time  
2        synchronized network and each of the plurality of packet profiles is a packet burst.

1                32.        The computer readable medium of claim 31, wherein the length L of each of the  
2        packet bursts is related to the Degree of Desynchronization (DoD) by an expression,  
3         $L = \frac{DoD}{ErrLim}$ , where ErrLim represents a maximum desired error in the segment bandwidth  
4        capacity determination.

1                33.        The computer readable medium of claim 32, wherein the time stamps made at  
2        each of the plurality of destination nodes are a first time stamp  $TS_{first}$  of the first packet of the  
3        packet burst received from each corresponding source node and a last time stamp  $TS_{last}$  of the  
4        last packet of the packet burst received from each corresponding source node, and the byte count  
5        measurements measure the bytes  $Bytes_{total}$  in each of the packet bursts received at each  
6        corresponding destination node.

1           34. The computer readable medium of claim 33, wherein an individual flow rate in bit  
2 per second due to each packet burst is calculated using an expression,  $Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}$ ,  
3 and a total flow rate through the test segment is the sum of all individual flow rates.

1           35. The computer readable medium of claim 30, wherein the network is a non-time  
2 synchronized network and each of the plurality of packet profiles is a packet stream, and a  
3 plurality of byte count measurements are made over a time measurement period T at each of the  
4 plurality of destination nodes.

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2           36. The computer readable medium of claim 35, wherein the length  $L_{multiple}$  of the  
3 packet stream is related to the Degree of Desynchronization (DoD) by an expression,  
4  $L_{multiple} = (4 * T) + 2\epsilon$ , where the time measurement period T is one half of DoD and epsilon  $\epsilon$  is  
5 used to compensate for small timing errors.

1           37. The computer readable medium of claim 36, wherein the time stamps made at  
2 each of the plurality of destination nodes are a plurality of time measurements  $MT_n$ , where n is  
3 an integer, each time measurements  $MT_n$  being separated by the time measurement period T and  
4 each measuring byte count over the period T since last time measurement  $MT_{n-1}$  in each of the  
5 packet streams received at each corresponding destination node.

1           38. The computer readable medium of claim 37, wherein an individual flow rate in bit  
2 per second due to each packet stream at the test segment is related to the smallest byte count

3 measurement Bytes<sub>total</sub> of all byte count measurements taken for the packet stream, the individual  
4 flow rate being calculated using an expression,  $Rate(bps) = \frac{Bytes_{total} * 8}{MT_n - MT_{n-1}}$ , and a total flow rate  
5 through the test segment is the sum of all individual flow rates.

1           39.     The computer readable medium of claim 30, wherein a link bandwidth capacity of  
2 a link is determined by measuring the bandwidth capacity of each of the segments that make up  
3 the link, the link having a maximum throughput of the slowest segment in the link.

1           40.     A computer readable medium for use in conjunction with a time synchronized  
2 network system including a plurality of nodes for determining segment bandwidth capacity, the  
3 computer readable medium including computer readable instructions encoded thereon for:  
4                 sending a packet burst from a source node to a destination node via a link, the link  
5 including at least the test segment; and  
6                 receiving the packet burst at destination node, the packet burst comprising a  
7 plurality of packets, wherein a first time stamp TS<sub>first</sub> of the first packet of the packet burst, a last  
8 time stamp TS<sub>last</sub> of the last packet of the packet burst and a byte count measurement measuring  
9 the bytes Bytes<sub>total</sub> in the packet burst are made at the destination node, the bandwidth capacity of  
10 the test segment in bit per second being calculated using an expression,

$$11 \quad Rate(bps) = \frac{Bytes_{total} * 8}{TS_{last} - TS_{first}}.$$

1           41.     The computer readable medium of claim 40, wherein the length L of the packet  
2     burst is related to the Degree of Desynchronization (DoD) by an expression,  $L = \frac{DoD}{ErrLim}$ , where  
3     ErrLim represents a maximum desired error in the bandwidth capacity determination

1           42.     A computer readable medium for use in conjunction with a non-time  
2     synchronized network system including a plurality of nodes for determining segment bandwidth  
3     capacity, the computer readable medium including computer readable instructions encoded  
4     thereon for:

5                 sending a packet stream from a source node to a destination node via a link, the  
6     link including at least the test segment, the packet stream having a length  $L_{single}$  that ensures at  
7     least two measurements for byte count measurement can be made at the destination node,  
8                 receiving the packet stream at destination node, the packet stream comprising a  
9     plurality of packets;

10                taking at least two measurements  $MT_{first}, MT_{second}$  at the destination node while  
11     the packet stream is being received, the two measurements  $MT_{first}, MT_{second}$  being separated by a  
12     measurement period T; and

13                making a byte count measurement measuring the bytes  $Bytes_{total}$  in the packet  
14     stream between the measurements  $MT_{first}, MT_{second}$  at the destination node, the bandwidth  
15     capacity of the test segment in bit per second being calculated using an expression,

$$16     Rate(bps) = \frac{Bytes_{total} * 8}{MT_{second} - MT_{first}}.$$

1        43.     The computer readable medium of claim 42, wherein the length  $L_{single}$  of the  
2     packet stream is greater than or equal to  $(2 * T) + 2\epsilon$ , where epsilon is used to compensate for  
3     small timing error.

1        44.     The computer readable medium of claim 42, further comprising computer  
2     readable instruction encoded thereon for triggering the destination SN to take the first  
3     measurement  $MT_{first}$  when it receives the first few packets in the packet stream, wherein the  
4     length  $L_{single}$  of the packet stream is greater than or equal to  $T + 2\epsilon$ , where epsilon is used to  
5     compensate for small timing error.

1        45.     The method of claim 1, wherein at least two of the plurality of packet profiles  
2     from at least two of the plurality of source nodes may be sent to the same destination node.

1        46.     The network system of claim 17, wherein at least two of the plurality of packet  
2     from at least two of the plurality of source nodes profiles may be received by the same  
3     destination node.

1        47.     The computer readable medium of claim 30, wherein at least two of the plurality  
2     of packet profiles from at least two of the plurality of source nodes may be sent to the same  
3     destination node.